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ABSTRACT

Research sought to determine whether memorization of rule statements before, during or after instruction in rule application skills would facilitate the acquisition and/or retention of rule-governed behavior as compared to no-rule statement memorization. A computer-assisted instructional (CAI) program required high school students to learn to a pre-specified criterion the application of five programing rules. Results indicated that rule statement memorization prior to rule application instruction did facilitate acquisition of rule-governed behavior. Despite this finding, however, no differences on a retention test in rule application skills could be attributed to the memorization of rule statements. (Author)

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Computer Applications Laboratory

EFFECTS OF THE MEMORIZATION OF RULE STATEMENTS ON PERFORMANCE, RETENTION AND TRANSFER IN A COMPUTER-BASED LEARNING TASK

Nelson J. Towle

September 30, 1973
Working Paper No. 11

Project NR 154-280
Sponsored by
Personnel & Training Research Programs
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ABSTRACT

This study sought to determine whether memorization of rule statements before, during, or after instruction in rule application skills would facilitate the acquisition and/or retention of rule-governed behavior as compared to no rule statement memorization. A CAI program required high school students to learn to a pre-specified criterion the application of five APL rules. Although rule statement memorization prior to rule application instruction did facilitate acquisition of rule-governed behavior, no differences on a retention test in rule application skills could be attributed to the memorization of rule statements.

INTRODUCTION

Much of the instruction presented in today's public school concerns the acquisition of what Gagné (1970) has called intellectual skills. Probably the most common type of intellectual skill being learned in the schools is the acquisition of principles or rules. The learning and subsequent application of rules enables an individual to respond to a great variety of situations in a regular and effective manner. When a student learns to apply a rule and his behavior becomes rule-governed, he may react to situations as classes of situations rather than being required to meet each situation as unique. Rule-governed behavior, then, is more efficient and effective than behavior that would be required if there were no rules that generalize to more than one situation.

Since much of school-based learning involves the learning and application of rules, it is imperative that an instructional paradigm for the teaching and learning of rules be both efficient in the short-term view of instruction, and effective in the longer-term view of retention and application of learned rules in transfer situations. Several instructional psychologists have offered instructional sequences thought to be effective in the teaching of rules. Three of the better defined rule instruction models are presented below.

Gagné (1970) suggests that an instructional sequence for the learning of rules should include the following steps:

Step 1: Inform the learner about the form of the performance to be expected when learning is completed.

Step 2: Question the learner in a way that requires the reinstatement (recall) of the previously learned concepts that make up the rule.

Step 3: Use verbal statements (cues) that will lead the learner to put the rule together as a chain of concepts, in the proper order.

Step 4: By means of a question, ask the learner to demonstrate one or more concrete instances of the rule.

Step 5: (optional, but useful for later instruction): By a suitable question, require the learner to make a verbal statement of the rule.

Evans, Homme, and Glaser (1962), in developing a system for the construction of programmed instruction sequences for the learning of rules, recommend the following sequence:

1) Present a frame which includes a verbal statement of the rule being learned, a complete example of the rule, and a partial example of the rule which requires a response from the student.
2) Gradually withdraw stimulus support with use of frames presenting the rule statement and a partial example, or a complete example and a partial example, or a complete example and an incomplete rule statement, each requiring a response from the student.
3) The instructional sequence should terminate when the student can deal effectively with a criterion testing situation in solving an example problem or stating the rule with minimum stimulus support.
4) When two or more rules are being presented, frames with incomplete rule statements and partial examples of each of the rules should be used to help the student discriminate between the two rules.

In a proposed model for adaptive instruction in rule teaching, P. F. Merrill (1972) suggests that the basic strategy would consist of a sequence of instructional frames that would employ a fading technique.

1) First, present a statement of the instructional objective, rule statement, several examples along with explanations of why they are examples of the rule (prompts), several partial examples requiring an active student response, appropriate feedback contingent on student responses, and prompts after the student made the incorrect response.
2) Same as (1) with the exception of deleting the prompts for the complete examples and different partial examples.
3) Same as (2) except for deletion of all prompts, objective statement, and complete examples.
4) Present complete example and several partial examples with accompanying feedback contingent on student responses.
5) Present an example, incomplete rule statement, and contingent feedback.
6) Presentation of incomplete rule statement with appropriate feedback.
7) Present several partial examples along with feedback contingent on student responses.

The P. F. Merrill model assumes that only the very low ability students would need to proceed through every frame in the sequence. Most students would be able to skip some of the fading frames, while very high ability students might be able to skip the highly prompted frames and some of the fading frames.

One of the essential distinctions that must be made in the discussion of rule learning is the one between a rule as an inferred capability or intellectual skill and the representation of a rule as a verbal statement

(Gagné, 1970). Gagné further suggests that, while knowing the verbal statement does not necessarily mean understanding the rule, it is thought, equally important to recognize that verbal statements usually enter into the process of learning a new rule in a crucial way. The verbal statement of the rule communicates and interrelates the concepts that the student must use or learn in order to apply the rule under consideration correctly. Gagné further suggests that, while knowing the verbal statement does not necessarily mean understanding the rule, it is thought equally important to recognize that verbal statements usually enter into the process of learning a new rule in a crucial way. The verbal statement of the rule communicates and interrelates the concepts that the student must use or learn in order to apply the rule under consideration correctly. Gagné proposes that a student may learn a rule without learning the verbal statement of the rule, although the human adult often learns both, in view of the fact that the rule statement may be used as a cue to the learning of the rule. Further, the learner may also be able to demonstrate the rule at some later time without being able to verbalize the rule statement or to recall it as a verbal statement.

Each of the three rule instruction models presented above recommends that a verbal statement of the rule being learned should be presented at the beginning of the instructional sequence. A reason for this procedure is that presentation of the rule statement at the beginning reduces the risk of the student "discovering" an incorrect rule. The verbal statement of the rule also serves as a cue to learning of the new rule. All three models also include the learning of the rule statement as an integral part of the instructional sequence in teaching rule application skills

Though each of the three models includes a requirement for the student to learn the statement of the rule, this skill cannot be considered as a demonstration of rule learning. Gagné proposes that being able to repeat the rule statement from memory would allow the student to talk about the rule on a later occasion. P. F. Merrill suggests that the ability to state the rule verbally may serve as a valuable cue and/or memory aid for subsequent application of the rule. Gagné would have the rule statements learned at the end of a sequence of instruction rather than the beginning. Both the P. F. Merrill and the Evans, et al. models integrate rule statement memorization within the rule application instruction.

The learning of rule application skills for a one-time application is obviously not an objective of the education system for students. The student must retain and be able to apply the rule in transfer problem solving situations to make the instruction worthwhile. Though generally recognized as important, many researchers report a lack of retention in school learned subjects (e.g., Layton, 1932; Lahey, 1941; Smeltz, 1956; Pressey, Robinson, & Horrocks, 1959).

Research in mathematics education and science education has indicated that intellectual skills such as problem-solving and rule-governed behavior are more resistant to forgetting as compared with lower order intellectual skills and verbal information (Lahey, 1941; Layton, 1932; White, as reported by Lahey, 1941; Gagné & Bassler, 1963). Because rules and principles are highly resistant to forgetting, the inability to correctly apply a rule at a time some distance from the original learning can be attributed to lack of retrieval of the correct rule rather than not having stored the rule in memory (Bruner, 1961).

That the problem of retrieval of information is as important as the initial storage of that information is further expounded by Tulving and Pearlstone (1966). They have postulated that retention performance is dependent upon both the degree of availability (available in storage) and the degree of accessibility (ease of retrieval) of the information required in the retention task. Studies cited previously have shown that rules are quite persistent in memory. It could be assumed, then, that once a rule has been learned it has also been stored in memory and is available in memory for use at some remote time. The retrieval of this rule for use in a retention task is now dependent upon its accessibility, i.e., having the proper cues present to initiate the systematic search necessary for its retrieval. Tulving and Pearlstone conclude that accessibility in recall of previously learned items is a function of having an appropriate method to retrieve items that are retained.

P. F. Merrill (1972) suggests that the ability to verbalize the rule statement may serve as a useful cue for application of the rule in a retention task. The present study attempted to determine the effect of memorizing rule statements in an initial rule application instructional sequence on retention of rule application skills. Also, the effects of rule statement memorization on initial rule application learning and on transfer of the rule application skills were investigated. In addition, the present study, assuming that memorizing rule statements will affect performance of rule application skills, sought to determine the proper placement of the memorization task within the instructional sequence.

RELATED RESEARCH

The literature review is divided into three sections. The first is a description of the concepts of "rule" and rule-governed behavior as held by several leading educational psychologists. The need is recognized for commonly accepted definitions of rule and rule-governed behavior. The second section is a summary of the literature which investigates several important variables to be considered in the initial learning of rules. The instructional task used in this study was developed to promote initial learning of the rules on the basis of these findings. The final section is a summary of the concepts of availability and accessibility in memory of previously learned information.

Rule and Rule-Governed Behavior

In a series of papers culminating in a thorough explication of his thinking in this area, Scandura (1972) deplores the lack of a commonly accepted definition as to just what rule-governed behavior is. Both Scandura (1972) and Gagné (1970) distinguish between behavior governed by a learned rule from the rule itself. Gagné states that a rule is not the verbal statement that simply represents the rule but is an internal state of the individual which governs his behavior. Gagné defined a rule (construct) as:

> An inferred capability that enables the individual to respond to a class of stimulus situations with a class of responses, the latter being predictably related to the former by a class of relations [1970, p. 19].

Scandura proposes:

> A rule may be defined as an ordered triple (D, O, R) where D refers to the determining properties of the stimuli, and O to the combining operation or transformation by which the derived properties (of the responses, R) are derived from the properties in D [1970, p. 520].

This could be expressed as the mathematical function R = O(D), where D is the domain, O the function, and R the range. Based on his extensive work in the concept-learning field, M. D. Merrill defines a rule as:

> A statement of relationship between two or more concept classes [1971, p. 37].

P. F. Merrill uses computer-science terminology to define rule-governed behavior as:

> The ability to perform a specified operation on inputs from a specified class of inputs to produce a specific output from a class of outputs [1972, p. 82].

Clearly each of these educational psychologists is describing the same kind of behavior. However, there is a need for clarifying the definition of rule and rule-governed behavior. It will be helpful to consider three interrelated concepts in order to more fully describe rule learning. These are the rule statement, the rule, and rule-governed behavior. A rule statement describes the procedure to be followed in performing a specified operation on inputs from a specified class of inputs to produce a specific output from a class of outputs. The rule is considered to be the procedure or operation described by the rule statement. Following this distinction, the common question "What is the rule?" should be stated as "What is the rule statement?" as the rule itself cannot be verbalized. The rule exists in the abstract world and can only be inferred from the rule statement or by observing rule-governed behavior. Rule-governed behavior is that behavior that would result from a student correctly applying the rule.

The ambiguous term "rule learning" may now be divided into two appropriately descriptive terms: (1) learning the rule statement which refers to learning to verbalize the rule statement, and (2) acquisition of rule-governed behavior which refers to the correct application of the rule. A student has learned a rule statement when he can verbalize a statement containing (1) a description of all of the critical steps in the rule application procedure, (2) a description of the class of inputs, and (3) a description of the class of outputs. This verbalized statement could be in the same form as it was presented to the student or it could be acceptable in a paraphrased form if it included the critical aspects of the rule. For example, consider the APL function, +/. The rule statement describing the function +/ is "If V is a string of numbers, +/V (sum V) gives the sum of the numbers." An acceptable rule statement could be "+/V means to add the numbers in the vector V together." Because both rule statements describe (1) the operation or procedure (add, sum), (2) the class of inputs (string of numbers, vector), and (3) the class of outputs (sum), they would be equally acceptable as an indication that the student had learned the rule statement.

Rule-governed behavior may be demonstrated by using the rule to respond correctly to a rule application situation which has neither been previously analyzed nor seen analyzed by the learner. After a student learns the application of a rule, his subsequent behavior may be termed rule-governed behavior. Considering again the APL function +/, a student demonstrates rule-governed behavior if, when presented with the problem +/ 4 3 1, he responds "8". Scandura (1972) makes the point that a student

may employ more than one rule to arrive at a correct response. Because this question is not central to this study, though important, it was assumed that a student applied the rule in question if he responded correctly to two out of three of the unsolved problems associated with the rule. The response "8" probably would not logically be associated with +/ 4 3 1 without the addition of 4+3+1.

The Learning of Rules

M. D. Merrill and Boutwell (1972) have developed an interesting task content-student behavior classification system for classifying cognitive behavior. The first dimension, task content, refers to those characteristics of a task identifying it as primarily a paired associate, concept, principle (rule), or problem task. The second dimension--student behavior--refers to the overt acts a student performs and the conditions under which these acts must be observed before they can be termed discriminated recall, classification behavior, rule-using behavior, or higher order rule-using behavior. The boxes on the diagonal of Figure 1 are the categories developed from Gagné's types of learning by M. D. Merrill (1971). The other boxes indicate combinations of task content and student behavior. In investigating the rule-using principle-content dimension categories, it is interesting to note that, theoretically, a student may use discriminated recall behavior to solve a problem in a rule-applying situation if he has seen that problem previously.

The next step of the student behavior axis (classification) indicates that when given an unencountered instance of a particular class, the student is able to indicate class membership. For instances of either the stimulus set or response set principle or problem classification is

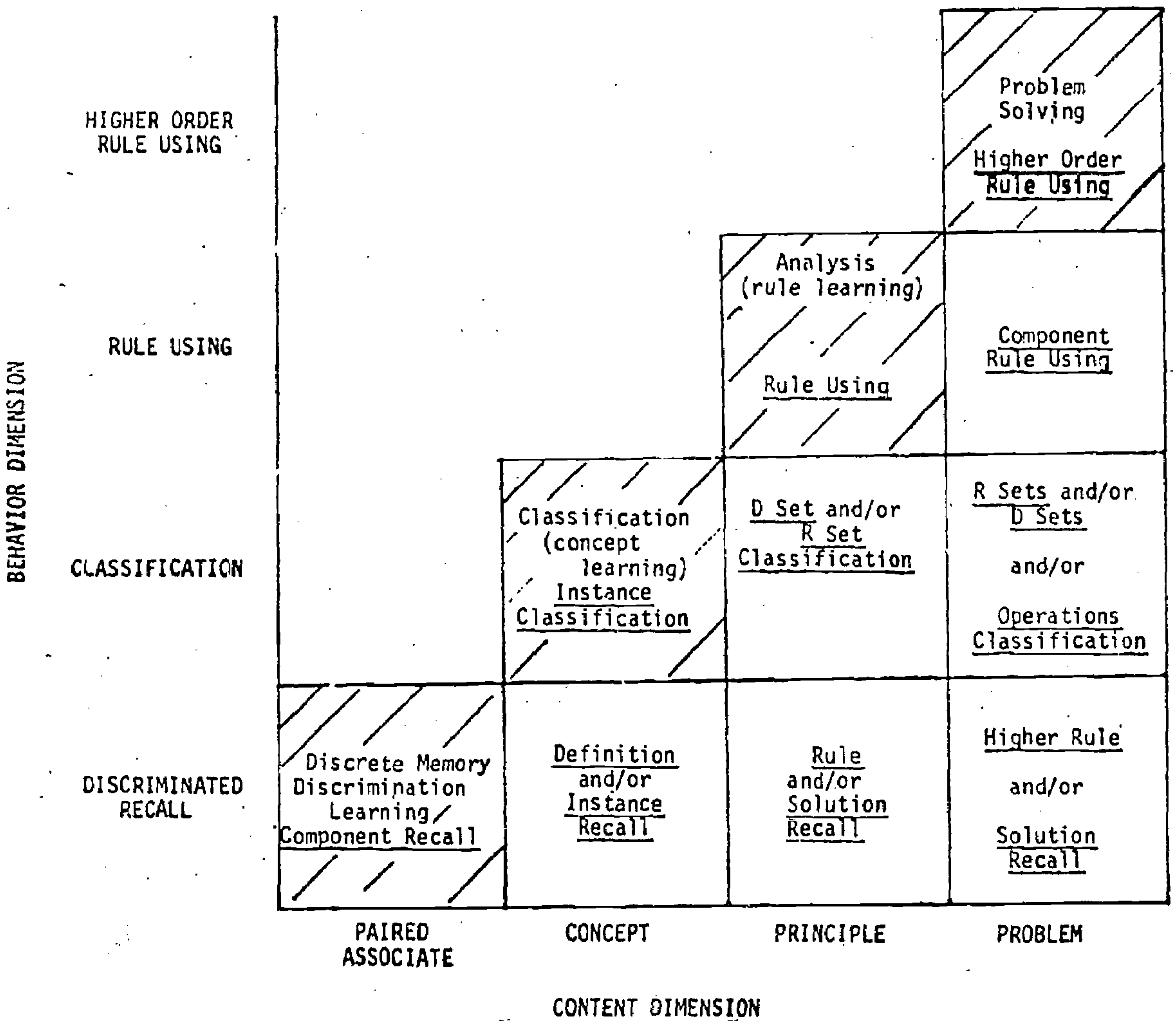

Figure 1. Two Dimensional Task Classification - - Behavior and Content

The diagonal(shaded boxes) are the categories included in the Gagné-Merrill hierarchy (Gagné 1965, 1970; Merrill, 1971). Parentheses are Gagné's terms. Underlined words are suggested terms used in the Merrill-Boutwell paper to classify tasks in both dimensions simultaneously.

Source: M. D. Merrill and R. C. Boutwell. Instructional Development: Methodology and Research, Working Paper No. 33. Brigham Young University, 1972.

frequently neglected in instructional programs. Students are often able to use a given operation once a problem has been identified as a member of the D set to which the operation applies. But frequently they are unable to determine when to use a given operation, i.e., to choose the proper rule. The level of student behavior that is most often considered when discussing rule or principle learning is that of rule-using behavior. A student has demonstrated rule-using behavior if, when given an unencountered instance of a particular D set, he can apply the operation O and produce the corresponding member of the R set. Obviously, unless the student is told that the particular problem presented is a member of the appropriate D set, he must first perform a classification task by correctly identifying the class membership of the instance.

Verbalization of Rule Statements

Gagné and Smith (1962) designed a study to investigate the role of verbalizing done by Ss during problem-solving situations. Results indicated that Ss who were instructed to say aloud their reasons for making each step in the solution to a practice problem reached a correct solution for the final task in fewer attempts than did Ss who were not required to verbalize. This difference increased as the problems became more difficult. In addition, those Ss who were required to verbalize their reasons for each problem solution step were able to formulate general principles of problem solution after correctly solving the final task problem better than those Ss not required to verbalize during the practice attempts.

Seidel and Rotberg designed a study to answer in part the question "Does verbalizing the content of a rule where separably measurable from mediating responses aid or hinder a concept-learning and problem-solving

capability?" (Seidel & Rotberg, 1966). To explore the verbalization factor, one-third of 60 paid volunteer high school students wrote computer programs and periodically wrote out the content of the rules used to guide the writing of computer programs (rules group); one-third wrote computer programs and periodically wrote down names they (students) gave the rules (naming group); and one-third wrote the computer programs without any verbalization of the rules (computer program only group). The task was presented via a programmed instruction text.

Results of the Seidel-Rotberg study showed that the students who were required to give back the rules in the words of the instructor (in this case, the instructional program) during the course of learning also were able to do this quite well on a criterion test. They, in fact, were able to assimilate and repeat the verbal material better than the other two groups noted as the naming and computer program only groups. As would be expected, the rules group took longer to complete the instructional material than did the other two verbalization groups. Further results indicated that the subjects required to write the content of the rules during training did not do as well in writing computer programs on the criterion test as the subjects who had simply to write the names of the rules during the training or the subjects who learned without either additional requirement. A retention test involving the application of concepts learned during the instructional program in writing computer programs showed no statistically significant difference among the three groups.

Availability/Accessibility of Rules

Bruner (1961) suggests that the principal problem of human memory is not storage, but retrieval. That we seem to be able to store a huge quantity of information Bruner infers from the fact that recognition (recall with the aid of maximum prompts) is so very good in human beings, particularly in comparison with spontaneous recall where we must retrieve stored information without external aids or prompts. Bruner indicates that the key to retrieval is organization or knowing where to find the information and how to get there.

In a related study reported by Tulving and Pearlstone (1966) subjects learned on a single trial lists of words belonging to explicitly designated conceptual categories. Lists varied in terms of length (12, 24, and 48 words) and number of words per category (1, 2, and 4). Immediate recall was tested either in presence or absence of category names as retrieval cues. Cued recall was higher than non-cued recall, the difference varying directly with list length and inversely with number of items per category. This finding was interpreted by Tulving and Pearlstone as indicating that sufficiently intact memory traces of many words not recalled under the non-cued recall conditions were available in memory storage but not accessible for retrieval. Further analysis of the data in terms of recall categories and recall of words within recalled categories caused Tulving and Pearlstone to suggest two independent retrieval processes. One is concerned with the accessibility of higher-order memory units and the other with accessibility of items within higher-order units. Organization of material, whether suggested by the experimenter or imposed by the subject, seems to affect recall performance primarily by making the

desired information more accessible in an otherwise limited biological retrieval system. This organization need not have any effect on the availability of the information in the storage.

In an unpublished study, Hannum (1972) reported that when a retrieval cue was used in conjunction with a retention test, performance in a rule application task was substantially improved. The effectiveness of the retrieval cue provides support for the position that intellectual skills are not forgotten or lost. The lack of ability to retain or reinstate previously learned rule-governed behavior may be due to a faulty retrieval scheme rather than a loss of the skill itself.

STATEMENT OF THE PROBLEM

The learning that takes place in school settings includes the very important category of learning of rules. Rules are probably the major organizing factor and, quite possibly, the primary one in intellectual functioning (Gagné, 1970). Rules guide the behavior of individuals in meeting many situations and in solving a variety of problems. The learning of a rule for a one-time application is obviously not an objective of the education of our schools. The student must retain and use the rule in retention and transfer problem-solving situations to make the instruction worthwhile. As an attempt to further the gains already made in devising the best rule instruction paradigm possible, the present investigation attempted to assess the effect of learning verbal statements of rules on the initial learning, retention, and transfer of rule-governed behavior.

Following Tulving and Pearlstone (1966) it was thought that rule statements having been previously learned would provide the cueing necessary to increase the accessibility of the appropriate rule-governed behavior in retention situations. It has been shown that the probability of the retention of once-learned rules is quite high. If behavior appropriate to a rule is learned but not accessible in memory for a later application, the problem can be assumed to be due to improper retrieval from memory. Emphasis in this paper was placed on attempting to determine the contributions of the memorization of rule statements to the acquisition and retention of rule-governed behavior.

Retention has also been shown to be unrelated to ability or achievement when the original learning is equalized (e.g. Klausmeier & Feldhausen, 1959; Shuell & Kappel, 1970; Smeltz, 1956). By insuring within the instructional program that all students perform to a prestated criterion, original learning by all subjects in this study can be assumed to be equated. Differences occurring in retention performance can be laid to the difference in the experimental variable--that of memorization of a rule statement. If, indeed, memorization of rule statements provides a cue for application of rules in retention tasks then the performance of the Ss having memorized rule statements should be higher than the performance of Ss who did not memorize rule statements.

The current investigation was undertaken to attempt to answer the following questions:

1. Does the memorization of rule statements facilitate performance during the initial learning of rules?
2. Does the memorization of rule statements during initial instruction facilitate performance during a retention test in rule application skills?
3. Does the memorization of rule statements during initial instruction aid in performance during a transfer task?
4. If memorization of rule statements during initial instruction facilitates rule application performance, at what point during the instructional sequence should the memorization requirement be made?
5. Do the experimental conditions interact with certain student abilities?

METHOD

Subjects

The subjects who participated in this study were taken from grades 9-12 at the Florida State University Developmental Research School. The University School student body is composed of students drawn from the Tallahassee, Florida, community so as to accurately reflect the characteristics of the community. The participants were selected randomly from the four grades depending upon the availability of students as dictated by the University School schedule. The data recorded from eighteen Ss who did not complete all three phases of the study were discarded. The data reported are based on the 124 Ss who completed all phases of the study.

Ability Measures

Several eminent educational psychologists have followed Cronbach's (1957) lead in promoting the search for student abilities, aptitudes (Cronbach & Snow, 1969), attributes (Tobias, 1970), or traits (AERA/SIG Individual Differences in Learning and Instruction, 1973) that interact with instructional treatments to produce different results depending on the level of the aptitude and type of treatment. On this basis, two ability tests were used to investigate relationships between cognitive abilities and task performance.

A series of studies by P. F. Merrill and his students (Merrill, 1970; Merrill, et al., 1972; 1973) have produced results showing Aptitude Treatment Interactions (ATI's) in a rule-learning task similar to that used in this study. Following the results of the P. F. Merrill studies, the Letter Sets Test from the Kit of Reference Tests for Cognitive Factors (French, Ekstrom, & Price, 1963) was selected as a measure of inductive reasoning. The Ship Destination Test from the same source was selected to measure general reasoning.

Experimental Task and Materials

The learning task used in this study was an adaptation of materials based on the APL programming language used in several previous studies (Merrill, 1972). The use of the APL programming language as the basis for the learning materials simplifies pretesting of subjects for previous experience with the language. Since the APL programming language is currently used in some high schools and universities, the results of this study can be generalized to other instructional efforts dealing with quantitative subject matter. The learning task consisted of five modules, each based on one APL rule. Each module consisted, depending upon the group assignment, of a rule statement, examples of correct application of the rule, problems to which the rule must be applied to compute the correct answer, and a requirement to memorize the rule statement. The results of previous research show that the first three rules are easy and the fourth and fifth rules substantially more difficult for Ss to learn.

Performance Measures

Rule application posttest and retention test. The posttest and retention test used in this study were essentially parallel forms in that both were composed of items that were sampled from the same pool of test items. The posttest contained a total of fifteen items, three items for each of the five rules. A coding error deleted one of the items on the retention test for Rule 1 so the retention test was composed of a total of fourteen items, two for Rule 1 and three for each of the other four rules. Copies of the posttest and retention test may be found in Appendix D.

Rule statement retention test. The rule statement retention test asked for the statements of the rules to be applied in problem situations. This test was composed of five items, one for each of the rules. Each item had a possible score of ten points making a possible total score of fifty.

Transfer task. The transfer task was composed of five modules, each based on one APL rule not presented previously. The program for each module of the transfer task required Ss to learn the correct application of one APL rule. A module consisted of one set of three examples of the correct application of the rule followed by three test items requiring correct application of the rule. As the purpose of the transfer task was to evaluate student performance rather than to provide instruction, no attempt was made to bring Ss' performance to a minimum criterion level. The maximum possible score on the transfer was fifteen.

Equipment

The instructional program was written in the Coursewriter II language and presented to the subjects by the IBM 1500/1800 computer-assisted instructional system at the FSU CAI Center. The learning materials and all tests in the APL-based instructional program were presented on the 1510 cathode ray tube (CRT). Employment of the CAI system in this study insured tight control over variable stimulus events for each subject that could not be controlled in a regular classroom situation.

Procedure

The study was administered in three sessions including an ability testing session, the instructional task and posttest session, and the retention test and transfer task session. The ability tests were administered to all subjects in one large group session and in one smaller group session, necessitated by the confines of the University School schedule. Immediately preceding the administration of the tests, a short explanation of the general purpose and schedule of the study was given to the subjects. The ability testing session (paper and pencil) lasted for about one hour. The instructional task session was presented by the CAI system in the FSU CAI Center. The subjects were randomly assigned to four groups. The four groups were a No Memorization of rule statement group, a Rule Statement Memorization Prior to Instruction group, a Rule Statement Memorization During Instruction group, and a Rule Statement Memorization After Instruction group.

Before receiving instruction in learning the APL rules, all <u>Ss</u> were presented with warm-up materials designed to familiarize each <u>S</u>

with the operation of the terminal and to indicate in advance of the presentation of the experimental materials what was expected of him during the instructional program.

Each of the five modules of the rule application instructional program presented to all groups consisted of three levels of instruction in rule application skills. The student was required to meet the minimum criterion performance of two-thirds of the rule application problems correct on each level before moving to the next level. The supporting stimuli of the rule statement and accompanying examples were faded from one level to the next until the criterion performance consisted of the presentation of a problem for which S was required to compute the correct answer without the aid of supporting stimuli. If the student did not meet the minimum performance requirement of two problems correct out of the three that were presented at any one level, he received up to four additional displays of that level. When criterion was reached at each of the three levels of rule application instruction, Ss then received the instructional module for the next task which depended upon the group to which S was assigned. The warm-up materials and rule application instruction materials are presented in Appendix A. The modules were presented randomly until all five rules were learned.

Review tests were presented after the completion of the second module and last module. Each review test was composed of three test items for each of the appropriate rules. Remedial review instruction was presented to those Ss not meeting the criterion of two out of three problems correct for each rule on the review test. After the remedial instruction was completed the S was then again administered the appropriate

review test. The review test and review materials are presented in Appendix B.

This basic sequence of instructional tasks was presented to all Ss with the following exceptions. The Rule Statement Memorization Prior group was required to memorize the rule statement prior to receiving instruction in application of the rule. The Rule Statement Memorization During group was required to memorize the rule statement after reaching the criterion of two-thirds correct of the problems presented in the first level of rule application instruction. The Rule Statement Memorization After group was required to memorize the rule statement after meeting criterion on all levels of application problems associated with the rule. The No Memorization group was not required to memorize the statement of the rule.

The rule statement memorization instruction consisted of several levels of requirements on the part of the Ss to complete a rule statement by typing the appropriate words using the terminal keyboard. The supporting stimuli of partial rule statements and examples were faded until the criterion performance consisted of the presentation of a partial example for which S was required to type the statement of the correct rule to be applied. The rule statement memorization materials are presented in Appendix C.

The instructional sequences for each of the four experimental groups based on this program for rule learning are presented in Table 1. Each line in the figure represents a frame composed of instructional components.

$ru + 3(eg) + 3(\widetilde{eg} + fb)$

$ru + 3(\widetilde{eg} + fb)$

$3(\widetilde{eg} + fb)$

No Memorization Group
Instructional Sequence

$ru + eg + \widetilde{ru} + fb$

$eg + \widetilde{ru} + fb$

$\widetilde{eg} + \widetilde{ru} + fb$

$\widetilde{eg} + \widetilde{\widetilde{ru}} + fb$

$ru + 3(eg) + 3(\widetilde{eg} + fb)$

$ru + 3(\widetilde{eg} + fb)$

$3(\widetilde{eg} + fb)$

Rule Statement Memorization
Prior Group Instructional
Sequence

$ru + 3(eg) + 3(\widetilde{eg} + fb)$

$ru + eg + \widetilde{ru} + fb$

$eg + \widetilde{ru} + fb$

$\widetilde{eg} + \widetilde{ru} + fb$

$\widetilde{eg} + \widetilde{\widetilde{ru}} + fb$

$ru + 3(\widetilde{eg} + fb)$

$3(\widetilde{eg} + fb)$

Rule Statement Memorization
During Group Instructional
Sequence

$ru + 3(eg) + 3(\widetilde{eg} + fb)$

$ru + 3(\widetilde{eg} + fb)$

$3(\widetilde{eg} + fb)$

$ru + eg + \widetilde{ru} + fb$

$eg + \widetilde{ru} + fb$

$\widetilde{eg} + \widetilde{ru} + fb$

$\widetilde{eg} + \widetilde{\widetilde{ru}} + fb$

Rule Statement Memorization
After Group Instructional
Sequence

Table 1. Instructional Sequences Presented to Each of the Four Experimental Groups.

The notation used in Table 1 is composed of components adapted and extended by P. F. Merrill (1972) from the Ruleg system (Evans, Homme, & Glaser, 1962). These include:

ru: Display of a verbal statement of the rule

$\widetilde{ru}$: An incomplete or partial statement of the rule which requires the student to respond by completing the rule statement

$\widetilde{\widetilde{ru}}$: A terminal situation which requires the student to verbalize the rule statement with minimum stimulus support

eg: An example of the rule

$\widetilde{eg}$: An incomplete example or problem which requires the student to respond by completing the example or solving the problem

$\widetilde{\widetilde{eg}}$: A terminal situation where the student is required to solve example problems with minimal stimulus support

n(eg): A series of n examples of the same rule

fb: Display of feedback concerning the correctness of a student's response to a problem or partial example

The instructional sequence consisted of the successive display of frames beginning at the top and proceeding to the bottom of the figure. The supporting stimuli such as rule statements and examples were faded gradually until the student was able to solve problems and verbalize the rule statement (if applicable) with minimal support. Figure 2 presents a flow chart depicting the entire instructional program.

Two weeks after the instructional session the subjects returned to the CAI Center to receive administration of the retention test and transfer task. The transfer task was composed of five additional APL rules that

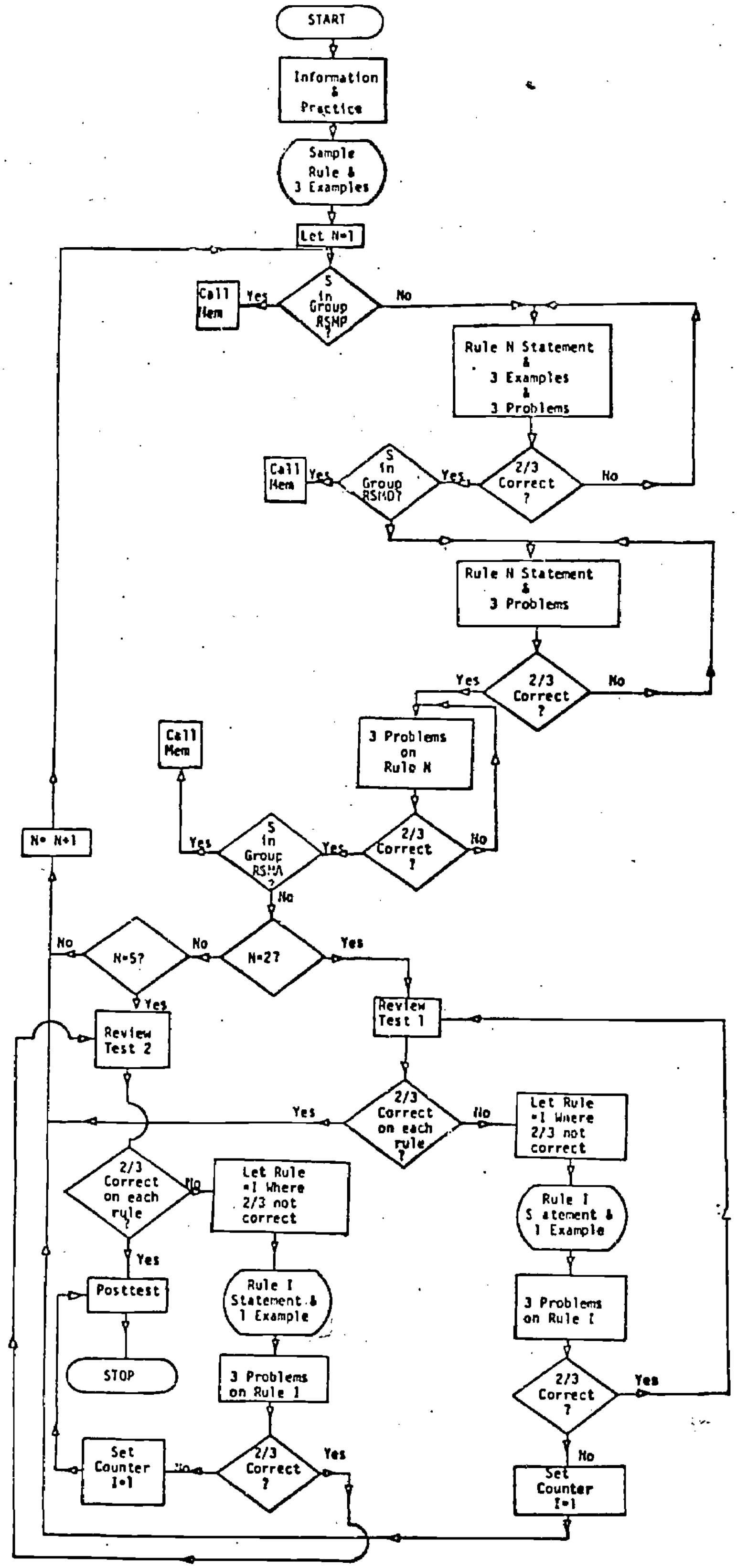

Figure 2. Flowchart of the Instructional Program

were not presented previously. The sequence of instruction in the transfer task paralleled that of the initial instructional task presented to the no rule statement memorization group with the exception that no rule statement was presented.

Dependent Measures

In addition to scores on the two cognitive ability tests, posttest, retention test, and transfer task described in previous sections, data were obtained for each S during the rule application instruction program on the following criteria: display latency, sample test item response latency, and number of sample test items attempted before meeting the minimum performance criterion required by the program. Display latency was the measure of the time between the initial display of study material and the start of the display of the first problem of that level of instruction. Sample test item response latency was the time between the initial display of a test item and the answering of that test item imbedded within the rule application instruction.

Data were also collected on the total amount of time required for each S to complete the instructional program including the rule statement memorization instructional materials. This total instructional time did not include the time required for testing activities.

Design and Analysis

The data presented in the Results section were collected on the performance of four treatment groups: the No Memorization group (n = 32), the Rule Statement Memorization Prior group (n = 33), the Rule Statement Memorization During group (n = 29), and the Rule Statement Memorization

After group (n = 30). Two designs were used for analysis of the data depending upon the dependent measure under examination. A four independent group design was used for the analysis of test scores and a four group by five repeated measures analysis of variance was used to evaluate several of the within instructional task measures. Other data were evaluated using two-tailed t tests. A positive bias correction was applied to those degrees of freedom used to test repeated measure factors when appropriate in ANOVA (Greenhouse & Geisser, 1959). The alpha level for statistical significance was .05.

Analysis of Aptitude by Treatment Interactions

To investigate the presence of Aptitude by Treatment Interactions, the relationships between scores on the two ability measures and task performance scores were operationalized in terms of the slope (amount of change in the criterion per unit change in the covariable) of the regression lines for each of the treatment groups. Linear regression analysis (Bottenberg & Ward, 1963) was used to evaluate the relationships between aptitude and performance. The procedure for computation of the F statistic and a description of the mathematical models used in each test are presented in Appendix E.

RESULTS AND DISCUSSION

A summary of mean percentage correct on the ability tests and on the task performance tests is presented in Table 2. All groups performed similarly on each test with the exception of the rule statement retention test where, as would be expected, the group that was not required to memorize rule statements performed less well than the rule statement memorization groups. All groups performed at a higher level on the rule application posttest than was required within the instructional program--81-88% on the posttest as compared to 67% required in the instructional program. Performance of rule-governed behavior on the rule application retention test was somewhat lower than that on the posttest but substantially higher than that on the rule statement retention test. This result is consistent with results of previous research indicating that intellectual skills such as rule-governed behavior are more resistant to forgetting than memorized verbal information (Lahey, 1941; Layton, 1932; Gagné & Bassler, 1963).

Analysis of variance $\underline{F}$ ratios for the instructional task test scores are also reported in Table 2. Table 3 presents a summary of the $\underline{F}$ ratios resulting from linear regression analyses used to investigate possible Aptitude by Treatment Interactions. A detailed discussion of the analyses of each dependent measure is presented in the following sections.

Table 2

Mean Percentage Correct on Ability Tests and Instructional Task Tests and Results of Analysis of Variance on Instructional Task Test Scores

Group	Ability Test		Instructional Task Test			
	Letter Sets	Ship Destination	Rule Application Posttest	Rule Application Retention Test	Rule Statement Retention Test	Transfer Task
No Memorization	50	40	81	59	25	63
Rule Statement Memorization Prior	58	49	88	63	43	71
Rule Statement Memorization During	55	44	88	61	36	64
Rule Statement Memorization After	57	55	85	63	47	70
ANOVAR, df = 3/120, F_c = 2.68			F = 1.205	F < 1.00	F = 2.956	F < 1.00

Table 3

Summary of F Values Resulting from Linear Regression Analyses to Investigate Possible Aptitude by Treatment Interactions on Instructional Task Test Scores

Covariable	df	Instructional Task Test			
		Posttest	Rule Application Retention Test	Rule Statement Retention Test	Transfer Task
Ship Destination Test Score	3/116	3.96**	2.70*	1.29	3.44*
Letter Sets Test Score	3/116	3.44	1.04	1.04	1.00

* $p < .05$
** $p < .01$

Posttest Score

Since the experimental procedure required all Ss to perform at a minimum criterion level on each rule module before proceeding to the next, no significant treatment differences were expected in mean posttest scores. The results from ANOVA suggest that the minor difference in treatment group posttest means was due to chance.

Figures 3 and 4 illustrate the different relationships between reasoning ability test scores and posttest scores in the four treatment groups. There was a greater positive relationship, as illustrated by the greater positive slope of the regression line, between general reasoning ability as indicated by the Ship Destination Test scores and posttest performance in the Rule Statement Memorization After group than in the three other groups. Similar results were found using scores from the Letter Sets Test as covariable and posttest scores as criterion. These results are somewhat surprising as the instructional program for learning rule-governed behavior was the same for the Rule Statement Memorization After group as for the No Memorization group. Yet, the relationship between reasoning ability and posttest performance was greater for Ss in the Rule Statement Memorization After group than for Ss in the No Memorization group. Apparently the requirement of memorizing a rule statement after having mastered the behavior required by the rule increases the relationship between reasoning ability and performance as compared to not being required to memorize the rule statement at all. The posttest performance of those Ss memorizing rule statements prior to receiving instruction in rule application skills was related very little, as illustrated by the nearly horizontal regression line, to reasoning

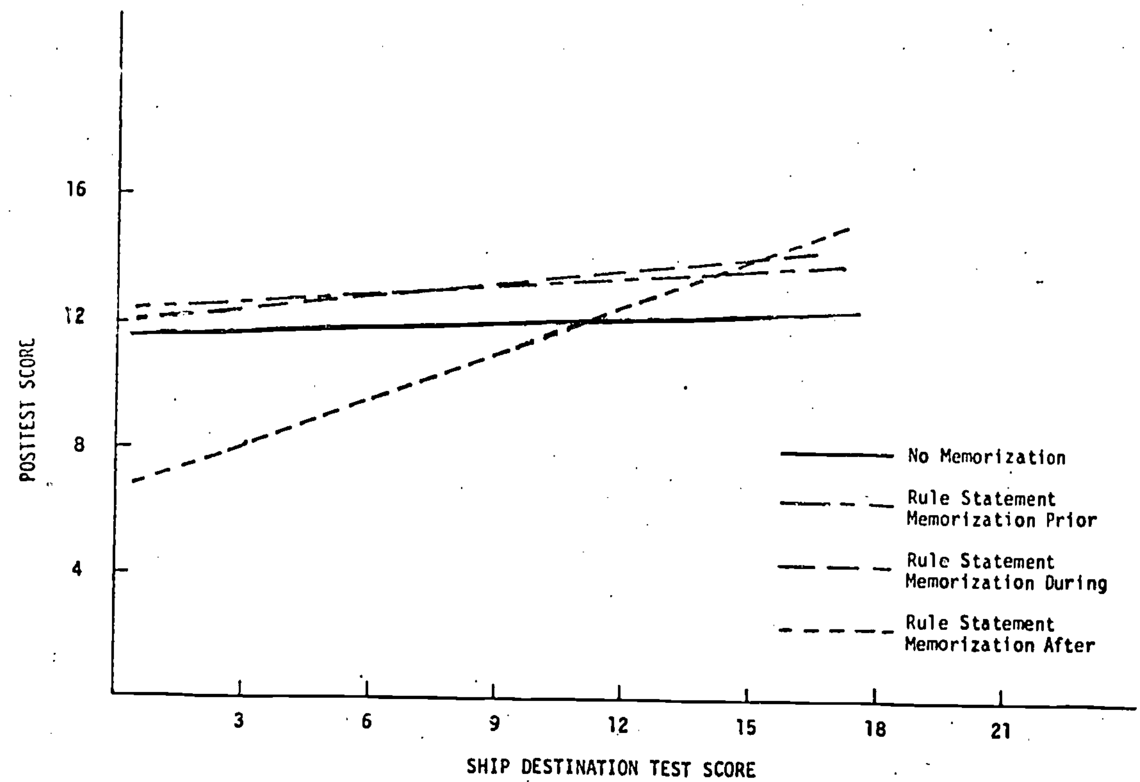

Figure 3. Interaction of Ship Destination Test Scores and Treatments with Posttest Score as Criterion

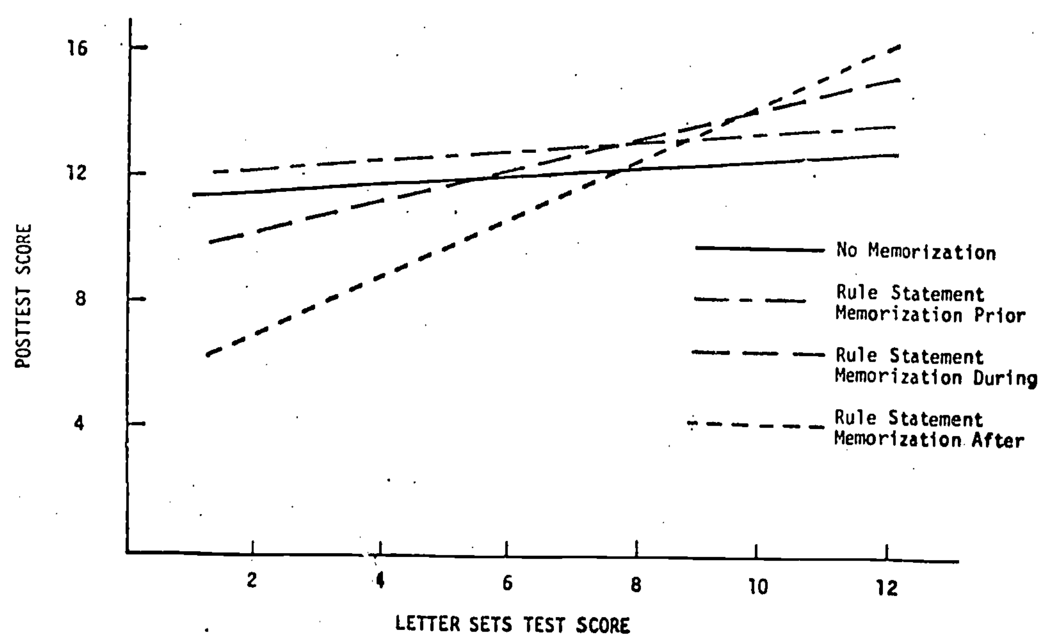

Figure 4. Interaction of Letter Sets Scores and Treatments with Posttest Score as Criterion

ability as was the posttest performance of those Ss not required to memorize rule statement. The relationship between posttest performance and reasoning ability of Ss in the Rule Statement Memorization During group is of little interest other than that it was between that of the Rule Statement Memorization After group and that of the No Memorization group.

Rule Application Retention Test Score

The expected significant differential effect of the treatments on performance on the rule application retention test was not supported by the data. One explanation for this result might be that the instructional program was equally effective in teaching all Ss the appropriate rule-governed behavior on a high performance level regardless of treatment group. This rule-governed behavior was then retained to a relatively high degree over the two-week period between the presentation of the instruction and the administration of the retention test. In fact, the mean score for all treatment groups nearly meets the performance level required by the instructional program. Several other reasons for the lack of treatment effect on retention of rule-governed behavior will be presented in a later section.

Figure 5 illustrates the relationship between Ship Destination Test Scores and rule application retention test scores for each treatment group. As with the posttest scores, the retention test scores were more positively related to general reasoning ability in the Rule Statement Memorization After group than in the other three groups.

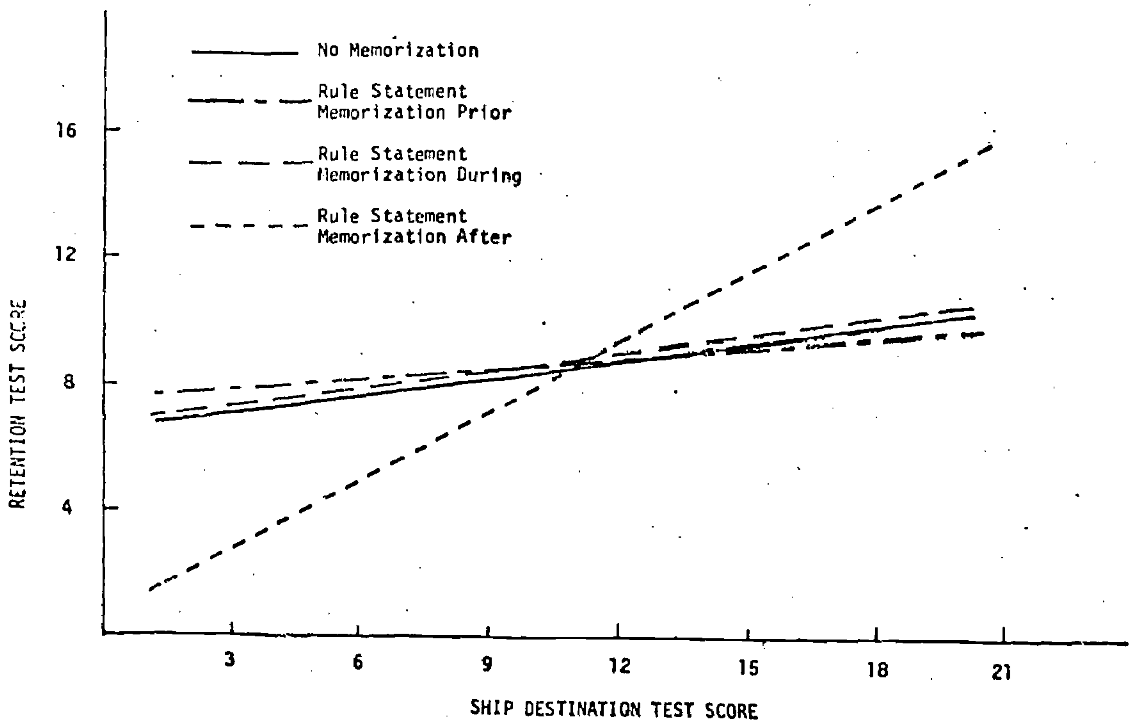

Figure 5. Interaction of Ship Destination Test Scores and Treatments with Retention Test Score as Criterion

Rule Statement Retention Test Score

The rule statement retention test required each S to type the statement of the rule that would be used to compute the correct answer to each of five problems, each problem representing one of the previously learned APL rules. These statements were evaluated independently by two expert APL programmers. A correct rule statement was awarded ten points with fewer points being given for partially correct answers. The product moment correlation between the total scores awarded each S by the two evaluators was .94 which indicated a high degree of scoring consistency between evaluators. For purposes of further analysis, the average of the two total scores for each S was used. As reported in Table 2, analysis of variance revealed a significant treatment effect. Subsequent t tests revealed no significant performance differences between the three rule statement memorization groups, or between the Rule Statement Memorization During group and the No Memorization group. However, mean scores indicated significantly lower scores for Ss in the No Memorization group than Ss in the Rule Statement Memorization Prior group ($t = 2.39$, $df = 120$, $p < .05$) and for Ss in the Rule Statement Memorization After group ($t = 2.79$, $df = 120$, $p < .05$).

Though Ss in the No Memorization group were not required to memorize rule statements at any time, their performance on the rule statement retention test did indicate that they could give minimally correct rule statements two weeks after rule application instruction. Surprisingly, the performance of Ss in the Rule Statement Memorization During group was not significantly different from that of Ss in the No Memorization group. All Ss who memorized the rule statements during rule application instruction

did, in fact, memorize the rule statements just as thoroughly as Ss in the other two rule statement memorization groups but at a different point in the total instructional program. The interruption of rule application instruction to fulfill the rule statement memorization requirement and then the subsequent return to the rule application instruction seems to have debilitated Ss' ability to restate the rule statement on the retention test.

Transfer Task Score

Though Ss in the Rule Statement Memorization Prior and the Rule Statement Memorization After groups performed better on the transfer task than did the other two groups, these differences were not significant. Figure 6 illustrates the differential relationships between reasoning ability as measured by the Ship Destination Test and transfer task scores. Though the slopes of the regression lines are slightly greater for all groups than those of the posttest and retention test scores, these regression lines follow a pattern similar to those for the posttest scores and retention test scores. The relationship between reasoning ability and performance on the transfer task is greater for Ss in the Rule Statement Memorization After group than for Ss in the other three groups. The effect of memorizing rule statements after reaching mastery on rule application skills seems to cause Ss to have a greater reliance on reasoning ability to perform on the transfer task.

Number of Rule Application Sample Test Items Attempted

The number of sample test items attempted during the rule application instruction is a gross measure of the subject's performance in the instructional program. The number of sample test items required to meet the

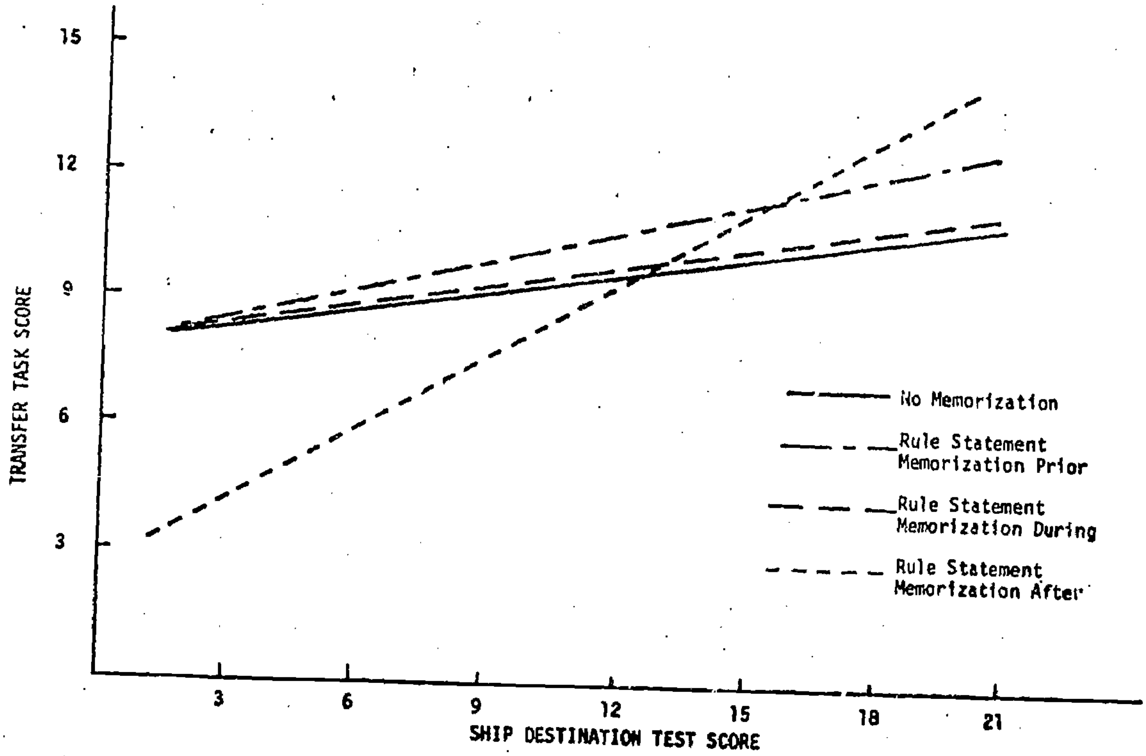

Figure 6. Interaction of Ship Destination Test Scores and Treatments with Transfer Task Score as Criterion

minimum performance criterion is directly related to difficulty S had in mastering the instructional materials. The minimum number of sample test items that any S would have received was forty-five--three for each of three levels of the five rule modules. Of great interest are the standard deviations of the Rule Statement Memorization Prior group (see Table 4). The instructional program presented to Ss in this treatment group produced rule-governed behavior so uniformly good that the variability was reduced to the point where analysis of variance on this data might be considered to be inappropriate. The range of number of sample test items attempted by Ss in the Rule Statement Memorization Prior group was 45-57 with a mean of 46.6. The ranges of sample test items for the No Memorization group, the Rule Statement Memorization During group, and the Rule Statement Memorization After group were 45-141, 45-123, and 45-115 respectively. From this evidence it would seem safe to conclude that requiring memorization of rule statements prior to rule application instruction is the best of the four instructional strategies to facilitate uniformly good rule-governed behavior with a minimum number of practice test items.

Though it is recognized that F ratios obtained from analysis of variance of these data may be suspect due to the lack of variability of scores in some of the cells and the lack of homogenity of variance across cells a 4 group x 5 Rule (repeated measures) ANOVA was performed. As would be expected from an examination of the means in Table 4 the results of this ANOVA revealed significant Treatment and Rule factors (see Table 5). The mean number of sample test items indicate that the Rule effect was due to the increased number of sample test items attempted in the more difficult

Table 4

Treatment Group and Rule Means and Standard Deviations
for Number of Rule Application Sample Test Items Attempted

Group		Rule 1	Rule 2	Rule 3	Rule 4	Rule 5	Overall Treatment
No Memorization	Mean	9.0	10.0	9.1	15.4	15.4	58.9
	SD	0	4.8	.5	10.2	10.8	21.8
Rule Statement Memorization Prior	Mean	9.0	9.2	9.0	9.4	10.2	46.6
	SD	0	.7	0	1.1	2.9	3.7
Rule Statement Memorization During	Mean	9.2	9.2	10.1	14.1	12.0	54.6
	SD	1.1	1.1	5.0	9.8	7.6	17.3
Rule Statement Memorization After	Mean	9.3	9.3	9.3	14.5	13.9	55.8
	SD	.9	.9	.9	11.6	11.6	21.2
Overall Rule	Mean	9.1	9.4	9.3	13.3	12.8	
	SD	.6	2.6	2.5	9.3	8.9	

Table 5

Analysis of Variance Summary for Number of Rule Application Sample Test Items Attempted

Source	df	MS	F
Treatment (T)	3	176.7	2.908*
Ss within T	120	60.8	
Rule (R)	(4) 1[a]	532.3	18.939**
T x R	(14) 3[a]	60.1	2.139
R x Ss within T	(480) 120[a]	28.1	

[a] df reduced by a factor of $\frac{1}{b - 1}$ where b = number of repeated measures (5) according to Greenhouse and Geisser (1959).

* $p < .05$

** $p < .01$

modules for Rules 4 and 5. Analysis of variance on the number of sample test items attempted in each rule module revealed a significant Treatment effect in the Rule 4 module ($F = 2.773$, $df = 3/120$, $p < .05$). Subsequent t tests revealed that Ss in the Rule Statement Memorization Prior group required fewer sample test items to meet the minimum performance level criterion than did Ss in the No Memorization group ($t = 2.67$, $df = 120$, $p < .05$), the Rule Statement Memorization During group ($t = 2.05$, $df = 120$, $p < .05$), and the Rule Statement Memorization After group ($t = 2.21$, $df = 120$, $p < .05$). There were no significant differences between the performance of the other three groups in number of sample test items attempted in the Rule 4 module.

Linear regression analysis was employed to probe for possible ATI effects on the number of rule application sample test items attempted. Figure 7 illustrates the significant interaction between Treatment and Ship Destination Test scores using number of sample test items as criterion. Figure 8 shows the plots of the regression lines illustrating the significant interaction between Treatment and Letter Sets Test scores with number of sample test items as criterion. Both figures show that number of sample test items has a high negative relationship to both general reasoning ability and inductive reasoning ability for Ss in the Rule Statement Memorization After group. This relationship is also present for Ss in the other groups but to a lesser degree. In fact, this relationship was substantially reduced for Ss in both the No Memorization group and the Rule Statement Memorization Prior group. The similarity in slopes of the regression lines for the latter two groups should be interpreted in light of the significant Treatment effect whereby the

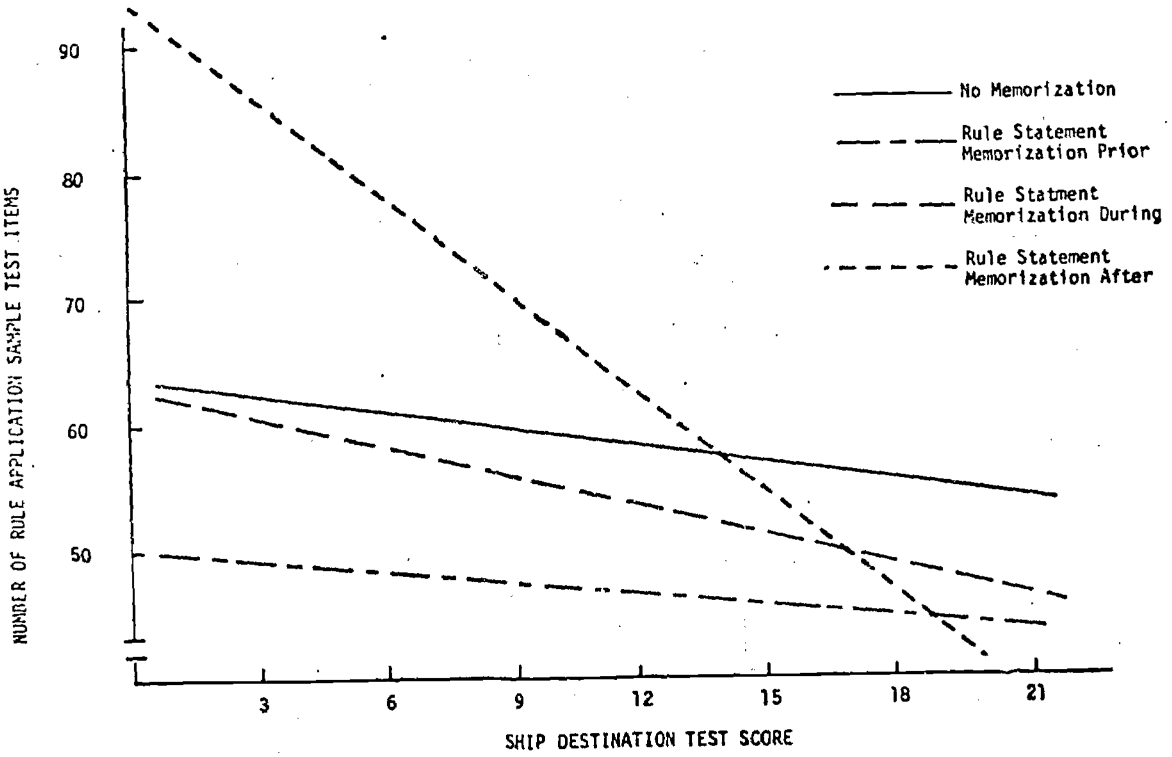

Figure 7. Interaction of Ship Destination Test Scores and Treatments with Number of Rule Application Sample Test Items as Criterion

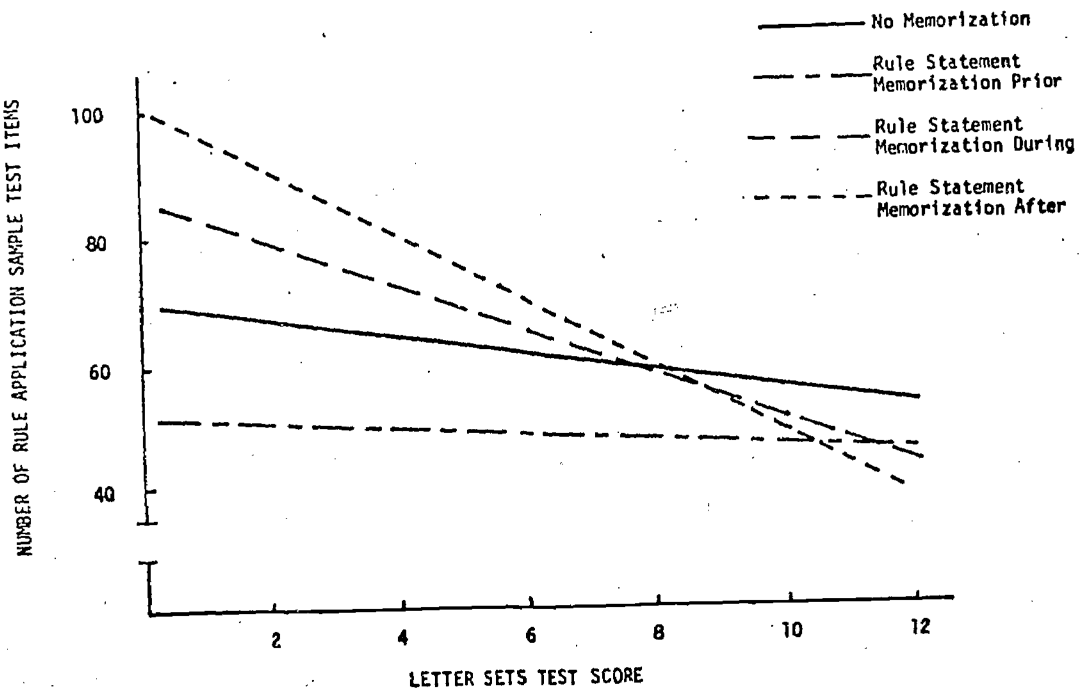

Figure 8. Interaction of Letter Sets Test Scores and Treatments with Number of Rule Application Sample Test Items as Criterion

instructional program for the Rule Statement Memorization Prior group reduced the mean number of sample test items required to meet the minimum performance criterion required of all Ss in rule-governed behavior.

Rule Application Display Latency

Another dependent measure used as an indication of Ss performance in the instructional program is display latency. The amount of time that the instructional materials are displayed is directly related to the difficulty S had in learning rule-governed behavior. As would be expected, mean display latency increased from about thirty seconds for each of the three previously demonstrated easier rule modules to about three minutes for each of the two more difficult rule modules (see Table 6). The instructional program which required Ss to memorize rule statements prior to receiving instruction in rule-governed behavior facilitated learning of rule application skills such that it produced uniformly low requirements for study time as compared to the instructional programs for the other treatment groups. When display latency for each of the five rule modules was totaled, the total display latency variance for the Rule Statement Memorization group was significantly less than the variance for the No Memorization group ($F = 5.42$, $df = 31/32$, $p < .01$), the Rule Statement Memorization During group ($F = 2.27$, $df = 29/32$, $p < .05$), and the Rule Statement Memorization After group ($F = 2.84$, $df = 28/32$, $p < .01$). Though the measure of display latency is not as important as other measures reported in this paper, these results do give further evidence as to the effectiveness of the instructional program for the Rule Statement Memorization Prior group in facilitating the acquisition of rule-governed behavior.

Table 6

Treatment Group and Rule Means and Standard Deviations for Rule Application Display Latency in Seconds

Group		Rule 1	Rule 2	Rule 3	Rule 4	Rule 5	Overall Treatment
No Memorization	Mean SD	29.8 18.9	30.9 26.3	27.0 19.0	190.4 171.6	263.0 229.9	531.0 375.4
Rule Statement Memorization Prior	Mean SD	20.5 17.9	19.7 8.3	14.8 8.9	79.9 82.8	101.8 84.2	237.0 161.2
Rule Statement Memorization During	Mean SD	37.1 17.8	39.7 27.5	28.9 27.0	242.5 156.4	182.8 129.1	531.0 242.9
Rule Statement Memorization After	Mean SD	31.1 19.1	27.2 14.5	27.0 20.9	156.4 133.6	203.8 196.1	445.5 271.6
Overall Rule	Mean SD	29.4 19.2	29.2 21.7	24.2 19.6	163.1 149.3	186.9 177.1	

Rule Application Sample Test
Item Response Latency

One additional measure used to indicate Ss' performance within the instructional programs is the amount of time S takes to respond to the sample test items. Although this measure was highly related to the number of sample test items attempted (product moment correlation of .72), it does give additional information of the effectiveness of the instructional programs. Consistent with the results of the analyses of several other dependent measures, the instructional program for the Rule Statement Memorization Prior group significantly reduced variability in total test item response latency as compared with the programs for the No Memorization group ($F = 7.7$, $df = 31/32$, $p < .01$), the Rule Statement Memorization During group ($F = 5.03$, $df = 29/32$, $p < .01$), and the Rule Statement Memorization After group ($F = 6.42$, $df = 28/32$, $p < .01$). As depicted in Table 7, the mean sample test item response latency for Ss in the Rule Statement Memorization Prior group was consistently less than that for each of the other three groups on each rule module. Mean total sample test item response latency indicated less time necessary to respond to test items for Ss in the Rule Statement Memorization Prior group than for Ss in the No Memorization group ($t = 3.502$, $df = 63$, $p < .05$), and Ss in the Rule Statement Memorization During group ($t = 3.168$, $df = 61$, $p < .05$). Although not significant at the alpha level of .05, the difference between performance of Ss in the Rule Statement Memorization Prior group and Ss in the Rule Statement Memorization After group ($t = 1.67$, $df = 62$, $p \approx .10$) was in the same direction with Ss memorizing rule statements prior to rule application instruction requiring less time to respond to the sample test items imbedded in the rule application instruction materials.

Table 7

Treatment Group and Rule Means and Standard Deviations for Rule Application Sample Test Item Response Latency in Seconds

Group		Rule 1	Rule 2	Rule 3	Rule 4	Rule 5	Overall Treatment
No Memorization	Mean	52.5	72.9	57.8	250.0	304.9	738.2
	SD	23.9	54.8	18.8	285.6	270.8	491.2
Rule Statement Memorization Prior	Mean	46.3	62.3	53.2	116.2	141.3	419.3
	SD	12.4	16.3	18.0	72.1	114.9	177.3
Rule Statement Memorization During	Mean	61.7	74.1	68.2	256.8	200.5	661.3
	SD	27.6	20.6	64.5	249.1	178.5	397.7
Rule Statement Memorization After	Mean	53.5	69.4	55.3	180.5	201.6	560.3
	SD	26.4	30.1	25.3	155.7	331.3	449.2
Overall Rule	Mean	53.3	69.6	58.5	199.8	211.9	
	SD	23.5	34.0	36.5	213.2	240.9	

While evidence has been presented that consistently supports the effectiveness of the instructional program requiring memorization of rule statements prior to rule application instruction in facilitating the acquisition of rule-governed behavior, the following measure will give an indication of the efficiency of the total instructional programs including the rule statement memorization program.

Total Instructional Time

The total time, excluding testing time, required by each S to complete the instructional program, including both the sections on rule application and on rule statement memorization, was recorded as a measure of the overall efficiency of the total program. Mean times for the No Memorization group, the Rule Statement Memorization Prior group, the Rule Statement Memorization During group, and the Rule Statement Memorization After group were 21, 53, 60, and 50 minutes respectively. The rule statement memorization groups required substantially more time to complete the instructional program than did the group not required to memorize rule statements. As the three rule statement memorization groups not only mastered rule-governed behavior but also performed the additional task of memorizing the rule statements, this finding is not at all surprising.

CONCLUSIONS AND IMPLICATIONS

In an introductory section of this paper it was proposed that the memorization of rule statements would increase the accessibility of previously learned rule application skills and, therefore, facilitate performance on a retention of rule application skills task. It was also anticipated that the memorization of rule statements prior to rule application instruction would facilitate the acquisition of rule-governed behavior by reducing the number of sample test items, and also reduce the amount of time taken in responding to sample test items.

It was further expected that memorizing rule statements would compensate for low inductive reasoning and general reasoning ability in performance during the learning task and in subsequent test situations. This effect would be evidenced by a reduced relationship between the reasoning abilities and task performances.

The design of the present study was such that all Ss were required to reach a minimum criterion performance at each instructional level of the task before they were allowed to go to the next level. The application of each rule was mastered before going to the next rule. This procedure was used to assure that all treatment groups would perform at the same level on the posttest. Unless all groups learned the original task equally well, any differential performance on retention or transfer measures could not be attributed to the effect of rule statement memorization on improving accessibility of rule application skills. The results

indicated that mean differences on the posttest were due to chance. Therefore, it was concluded that all groups had learned behavior governed by the five APL rules equally well. Because overall performance on the posttest was better than the two-thirds correct required by the instructional program it was then concluded that the instructional program was effective in producing Ss who could exhibit the appropriate rule-governed behavior.

The expectation that the groups memorizing rule statements would perform significantly higher on the retention of rule application skills test was not supported. This may be due to three factors. First, since there was a small decrease (20-30%) in performance between the posttest and retention test for all treatment groups, the retention interval of two weeks may have been too short for the effects of memorization of rule statements to be seen in retention of rule application skills. A second factor relates to the proficiency in rule application demonstrated by Ss after completing the instructional program. The success of the computer-presented instructional program in promoting this high level of performance in all experimental groups may have prevented the memorization of rule statements from differentially affecting performance in retention of rule application skills. Thirdly, the relatively poor performance exhibited by all Ss on the rule statement retention test indicated that the rule statements were not easily accessible in memory, and, therefore, could not have aided the recall of rule application skills.

The expectation that the rule statement memorization groups would perform significantly better on a rule statement retention test than the group that did not memorize rule statements was partially supported. Those Ss memorizing rule statements either before or after the rule

application instruction outperformed those who were not required to memorize rule statements. The Ss who were interrupted in their rule application instruction to memorize the rule statements may have found that this interruption interfered with their concentration in preventing proper organization and storage of accompanying cueing mechanisms in memory for easy and accurate retrieval of the rule statements in the retention test situation.

No significant treatment differences in transfer task performance were found. The transfer task used in this study did not include the presentation of rule statements, and, therefore, may not have been similar enough to the original instructional program to cause the factor of rule statement memorization to have an effect on the transfer task performance.

As expected, treatment effects within the rule application instructional program were consistent in favoring the memorization of rule statements prior to rule application instruction, especially in the modules associated with the more difficult rules. The five APL rules used in the instructional program could be characterized as follows: Rules 1-3 were quite easy, Rule 4 was more difficult and quite complex, and Rule 5 was most difficult but straightforward. The prior memorization of rule statements aided in reducing the number of sample test items required before reaching the minimum criterion performance for Rule 4, and in general reducing the amount of instructional display time and the amount of time required to respond to the sample test items. It seems that memorizing rule statements prior to rule application instruction enables the student to be more efficient in the acquisition of rule-governed behavior. However, this effect must be tempered with the fact

that the total instructional program including instruction in rule application skills and memorization of rule statements required, on the average, over twice the amount of time that the rule application skills instructional program required by itself.

The expectation that the memorization of rule statements would reduce the relationships between task performance and reasoning ability as measured by the Ship Destination Test and the Letter Sets Test was not supported. The instructional program that required no memorization of rule statements and the program that required memorization of rule statements prior to rule application instruction produced similar results in minimizing the relationships between reasoning ability and performance in many of the instructional task measures and associated tests. The memorization of rule statements after meeting minimum criterion performance in rule-governed behavior increased the relationship between reasoning ability test scores and task performance. Why this relationship was greater in the Rule Statement Memorization After group than in the No Memorization group is not clear. Apparently, the memorization of rule statements after mastery of rule-governed behavior may have little or, possibly, negative meaning to the student in the learning of rule-governed behavior. From an information processing point of view, this memorization may provide additional information that is an unusable overload for those Ss lower in reasoning ability, and which, in turn, debilitates both the acquisition and retention of rule-governed behavior.

Memorization of rule statements during the rule application instruction had no definitive effect on task performance or on the relationship between reasoning ability and task performance. As such, it should not

be used as an instructional strategy for teaching rule application skills.

Implications for Rule Instruction

The instructional problem of whether to require students to memorize rule statements or not as a part of learning rule application skills cannot be conclusively solved on the basis of the results of this research. However, several tentative suggestions can be made.

1) If memorization of a rule statement is required in an instructional program designed to teach rule application skills, the memorization requirement should be fulfilled prior to instruction in rule application skills.
2) If the goals of an instructional program are associated with only rule-governed behavior in long- or short-term retention situations, memorization of rule statements is not necessary.
3) If total instructional time is limited and all instruction must take place during this time, memorization of rule statements should not be included in the instructional program.
4) If some goals of an instructional program are associated with facilitating performance during the acquisition of rule-governed behavior, memorization of rule statements should be required prior to instruction in rule application skills.
5) If one purpose of the instructional program is to reduce learning errors and accompanying frustration and/or anxiety, memorization of rule statements should be required prior to instruction on rule application skills.

The results of this study indicate that the instructional strategy used in developing the instructional program to teach rule application

skills was effective in producing appropriate rule-governed behavior. This strategy was based on the work of several educational psychologists and on the results of previous research by the author. The following seven instructional components are presented as being useful in promoting the acquisition of rule-governed behavior.

1) Presentation of a statement explaining the purpose of the instruction and, in general terms, what is expected of the student during and after the instruction.
2) Presentation of a statement of the rule to be learned accompanied by at least one example to show the student how the rule is correctly applied.
3) (optional) Require the student to memorize the rule statement.
4) Presentation of the rule statement and several examples for study by the student, followed by several problems requiring active student responses which are followed by appropriate feedback.
5) Presentation of the rule statement and, without any examples, several new problems requiring student response followed by appropriate feedback.
6) Presentation of several additional problems without support of either the presentation of the rule statement or examples followed by feedback.
7) After several rules have been learned following the above six steps, the student should be presented with several problems, each requiring a different rule for solution to require the student to discriminate between learned rules and to choose the appropriate rule to correctly solve the problem.

Implications for Future Research

The instructional program used in this research produced such excellent results in enabling all subjects, regardless of treatment, to exhibit appropriate rule-governed behavior that the factor of memorization of rule statements may not have had the expected effect on retention of rule application skills. Research should be conducted using a less structured rule application instruction program to determine if the memorization of rule statements facilitate retention of rule application skills performance in a situation other than that of mastery learning such as was used in this research.

The unexpected effect that was seen in the performance of Ss who memorized rule statements after mastering rule-governed behavior should be investigated further to determine if the increased relationship between reasoning ability and performance was caused by memorization of the rule statements or if memorization of any statement unrelated to the application of the rule would have the same effect. Perhaps the memorization of the rule statement disturbs the cognitive organization of the already learned rule-governed behavior. Or the abrupt shift from learning a skill to learning verbal information may be the cause of this effect rather than the content of the material being memorized.

The lack of the memorization of rule statement effect on retention of rule application skills may have been due to the relatively poor performance in retaining the rule statements. Though performance on the rule application retention test and performance on the rule statement retention test were related (product moment correlation of .68) the rule statements may not have been accessible in memory to a great enough degree to aid in

retrieval of appropriate rule application skills. Reteaching the verbalization of rule statements immediately prior to a rule application retention test would assure that rule statements be available to aid in retrieval of previously learned rule application skills.

The generalizability of these results to instruction on rules in other than quantitatively oriented topics should be examined. Instructional programs using rules of grammar, rules of logic, or rules governing an athletic event might be appropriate to these further investigations of the effects of memorization of rule statements.

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